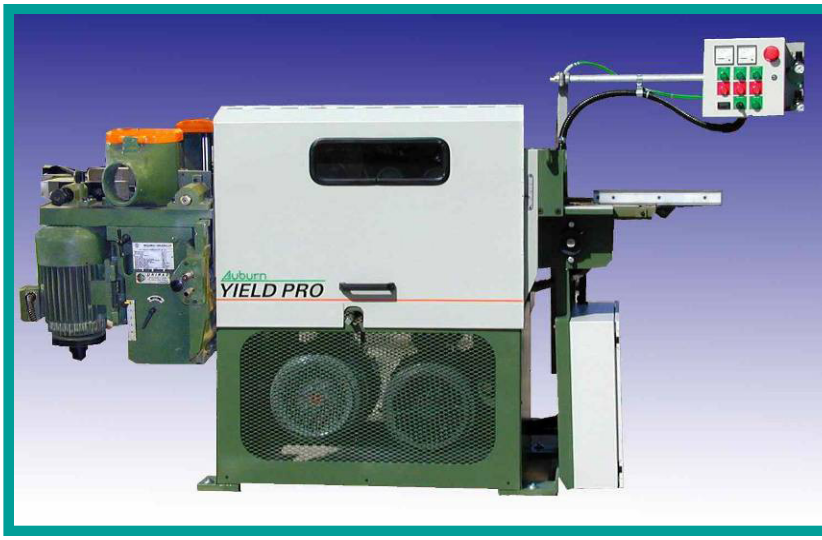
ESTCP
Cost and Performance Report

(SI-0309)



Reclamation of Wood Materials Coated with Lead-Based Paint

May 2008

ENVIRONMENTAL SECURITY
TECHNOLOGY CERTIFICATION PROGRAM

U.S. Department of Defense

Report Documentation Page	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE **MAY 2008**	2. REPORT TYPE	3. DATES COVERED **00-00-2008 to 00-00-2008**

4. TITLE AND SUBTITLE **Reclamation of Wood Materials Coated with Lead-Based Paint**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Environmental Security Technology Certification Program (ESTCP),4800 Mark Center Drive, Suite 17D08,Alexandria,VA,22350-3605**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S)
	11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**42**	

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ACRONYMS AND ABBREVIATIONS

ACSIM	Assistant Chief of Staff for Installation Management (Army)
AGSC	Ahtna Government Services Corporation
AMI	Auburn Machinery, Inc.
bf	board foot (wood volume equivalent to 12 x 12 x 1 inch)
C&D	construction and demolition (waste debris)
Cal WET	California Waste Extraction Test (as defined in CCR Title 22)
CCR	California Code of Regulations
CEQA	California Environmental Quality Act (1970)
CERL	Construction Engineering Research Laboratory
CFR	Code of Federal Regulation
CIWMB	California Integrated Waste Management Board
DoD	Department of Defense
DOT	Department of Transportation
DPW	Directorate of Public Works
DTSC	Department of Toxic Substances Control
ERDC	Engineer Research and Development Center
ESTCP	Environmental Security Technology Certification Program
FPL	Forest Products Laboratory
HASP	Health and Safety Program
HEPA	high efficiency particulate air (filter)
HUD	Department of Housing and Urban Development
LBP	lead-based paint
lf	linear feet
MBUAPCD	Monterey Bay Unified Air Pollution Control District
MCDH	Monterey County Department of Health
MTCE	metric tons of carbon equivalent
$MTCO_2E$	metric tons of carbon dioxide equivalent
MU	mobile unit
NAL	National Analytical Laboratories, Inc.
NDCEE	National Defense Center for Environmental Excellence
NIOSH	National Institute for Industrial and Occupational Health
NOV	notice of violation
OSHA	Occupational Safety and Health Administration

ACRONYMS AND ABBREVIATIONS (continued)

PEL	Permissible Exposure Limit
PPE	personal protective equipment
PWBC	Public Works Business Center (U.S. Army)
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
T&G	tongue and groove
UFGS	Unified Facilities Guide Specifications
USACE	U.S. Army Corps of Engineers
USARR	USA Recovered Resources
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
WARM	Waste Reduction Model
WET	waste extraction test
WWD	Wood Waste Diversion, LLC, Pacific Grove, CA
WWII	World War II

ACKNOWLEDGEMENTS

Funding for this demonstration was provided by the Environmental Security Technology Certification Program (ESTCP) under Sustainable Infrastructure Project 200309, “Reclamation of Wood Materials Coated With Lead-Based Paint (LBP).”

Several individuals and organizations participated in this demonstration and provided review, guidance, information, access to facilities, and logistics support that were valuable to the success of this project. The following organizations are gratefully acknowledged:

- California Army National Guard, Camp Roberts, CA
- U.S. Army Corps of Engineers (USACE), Mobile District
- U.S. Department of Agriculture (USDA), Forest Products Laboratory (FPL)
- Department of Environmental Engineering Sciences, University of Florida
- Wood Waste Diversion, LLC (WWD)
- Ahtna Government Services Corporation (AGSC)
- U.S. Naval Facilities Engineering Service Center
- U.S. Air Force Center for Environmental Excellence

The lead organization was the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratories (ERDC-CERL) located in Champaign, IL. ERDC-CERL coordinated the demonstration at the Camp Roberts California Army National Guard installation in west-central California. Auburn Machinery provided the equipment and technical expertise in the processing of LBP-coated wood. In coordination with Auburn Machinery, WWD performed the building deconstruction to provide the process feed materials. The FPL and Auburn Machinery evaluated the conversion into value-added products and to develop markets for these environmentally friendly products. All parties worked together to ensure that the demonstrations met the needs of the Department of Defense (DoD) and the private sector, and assisted in technology transfer activities, including to wood manufacturing companies, engineering and construction companies, and state agencies exploring wood recovery operations in deconstruction projects.

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1.0 EXECUTIVE SUMMARY

1.1 BACKGROUND

Tens of thousands of temporary wooden buildings from the World War II (WWII) era, consisting of more than 50 million sf of floor area, await removal from numerous U.S. military installations. Wood coated with lead-based paint[1] (LBP) makes the removal and disposal of debris from these buildings expensive and also consumes rapidly shrinking landfill capacity. In California, more than 40,000 wooden buildings must be removed from military sites. Wrecking and landfill disposal is the common building removal method; reuse or recovery of the LBP-coated wood is seldom attempted. Removal of the LBP from wood waste could reduce the burden on landfills by 60–75%. Recovered wood could be reprocessed to make high-quality, revenue-generating wood products such as flooring, siding, paneling, and trim. Much of this old-growth lumber would be valuable in the antique architectural millwork market.

1.2 OBJECTIVES OF THE DEMONSTRATION

This project demonstrated a process designed to efficiently reclaim construction materials from obsolete buildings in order to recover their economic value instead of discarding them into a landfill. The objective was to validate the effectiveness of an innovative, environmentally compliant building deconstruction process and woodwork-milling mobile unit (MU) designed to economically and safely reclaim vintage exterior siding and dimensional lumber coated with LBP. In addition to deconstruction, remanufacturing operations, and debris processing, the demonstration encompassed marketing the recovered wood products, evaluating waste-reduction performance, and estimating the cost-effectiveness.

1.3 REGULATORY DRIVERS

Handling, transportation, and disposal of LBP are governed by:

- The Resource Conservation and Recovery Act (RCRA)
- 29 Code of Federal Regulation (CFR) Part 1926, The Occupational Safety and Health Administration (OSHA) Construction Safety Standards; Part 62, Lead in Construction
- The Department of Transportation (DOT)
- Lead-Based Paint Poisoning Prevention Act of 1971
- 16 CFR Part 1500.230 “Guidance for Pb in Consumer Products”
- California state and county agencies
    - California Environmental Quality Act (CEQA), 1970
    - California Integrated Waste Management Board (CIWMB)
    - California Department of Toxic Substances Control (DTSC)

[1] Lead-based-paints were produced in the United States as early as 1804. Lead pigments were used extensively in exterior and interior oil paints up to the mid-1970s.

- Monterey County Department of Health (MCDH)
- Monterey Bay Unified Air Pollution Control District (MBUAPCD)

1.4 DEMONSTRATION RESULTS

The total building removal cost was originally projected to be $12/sf of building, but the actual cost was $15.49/sf. It had been estimated that each building could be removed in 6 working days, but the contractor spent an average of 8 work days per building. The MU's production rate exceeded the estimated 9000 linear feet (lf) of painted siding per day and achieved an average output of 11,240 lf/day. Quality expectations for the planed output were met or exceeded. Waste reduction of 60% was initially expected, but the actual figure was 80%. The sale price of the reprocessed lumber was lower than expected but reasonable.

Safety precautions for airborne lead and residual lead in the processed wood were effective, and actual measured concentrations were far below any threshold or action levels. No accident reports were filed, but two incidents of contractor personnel stepping on nails were recorded. The common practice of wearing stainless steel sole inserts would have prevented these injuries. Overall, MU performance met expectations. Building removal costs above the projected estimate resulted from certain cost-ineffective operational decisions by the contractor and the resolution of a contractor reimbursement issue.

1.5 STAKEHOLDER AND END-USER ISSUES

The results of this demonstration enable both the public and private sectors to evaluate the technology in comparison with their own scales and capabilities. The Army installation Directorate of Public Works (DPW) must consider the cost of the technology and its effectiveness in reducing the volume of wastes needing to be trucked to hazardous waste landfills. Responsible personnel will have to decide whether enough lead-contaminated materials will be generated to warrant acquiring a suitable planing machine, or whether contracting for the services would be more appropriate. Installation management will also need reliable projections of disposal cost avoidance and a realistic assessment of whether any significant amount of revenue will accrue from the marketing of value-added products made from the recovered wood. When contracting for services, the DPW must be sure to hire contractors with expertise in building deconstruction and materials reclamation in order to fully meet the Army's facility removal needs and budgets. The contractor must possess specific technical capabilities, operational proficiencies, and marketing insight necessary to cost-effectively deconstruct a building, efficiently separate worthless debris from valuable feedstock, and identify profitable markets for the reprocessed wood. Due diligence in contractor selection should avoid the unnecessary cost and performance problems encountered in the demonstration.

2.0 TECHNOLOGY DESCRIPTION

2.1 TECHNOLOGY DEVELOPMENT AND APPLICATION

A straightforward way to divert and reclaim the large amounts of LBP-coated wood currently going into landfill is to mechanically plane the paint film from the board surface. With the LPB removed, the board can then be further machined into value-added profiles for use as flooring, siding, or wainscoting. The shavings from the planing process, which may include a surface layer of lead-contaminated wood, represent a small fraction of the volume of the original board.

The advantage of mechanical paint removal versus chemical or thermal stripping is that it leaves no hazardous chemical sludge to dispose of—the waste product is dry and concentrated, ready for appropriate disposal or further processing to reclaim the lead. The shavings can be treated with portland cement or a phosphate to stabilize the lead compounds, and landfilled. In California and other states, lead treated in this manner costs less than by other methods to landfill.

A practical, self contained system specifically designed to safely and economically remove LBP from wood—the MU demonstrated in this project—was conceived in 2000 and demonstrated on a laboratory scale through leveraging with deconstruction demonstrations at the former Fort Ord, CA[2].

2.2 PROCESS DESCRIPTION

The central feature of the MU is the YieldPro wood planing and sawing machine made by Auburn Machinery, Inc.[3] (AMI) (Figure 1), which can process up to three surfaces of wooden stock using any of several different configurations. The configuration evaluated in this demonstration consisted of three planing heads (top, bottom, and one side head) and a side-ripping blade. (Hogging blades can also be used for greater material removal.) The MU is capable of machining three surfaces simultaneously in a variety of configurations.

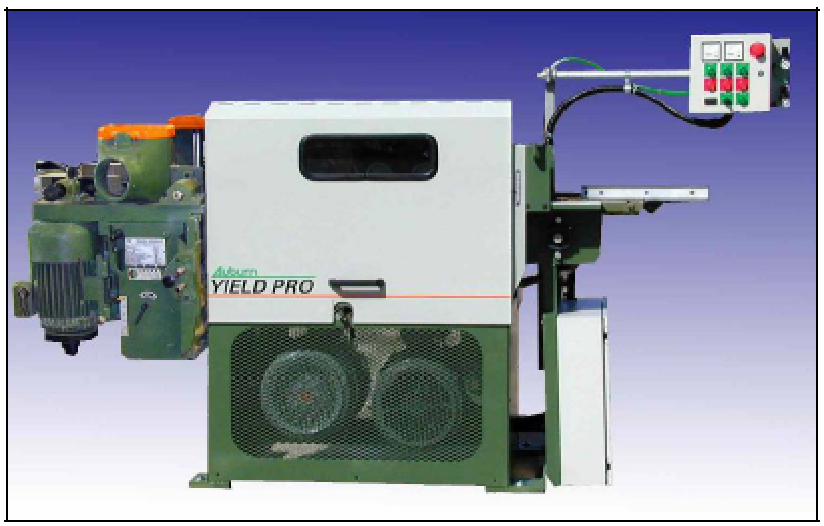

Figure 1. Auburn YieldPro wood milling machine.

[2] Falk et al. 2006.
[3] A subsidiary of Auburn Enterprises, Auburn, ME.

The YieldPro was housed in a self-contained mobile trailer that includes standard commercial electrical generation, air compression, dust collection, residue storage, and fire-suppression systems. The dust collection system is equipped with a high efficiency particulate air (HEPA) filter to contain shavings, sawdust, and debris. The residue storage chamber is equipped with an auger conveyer for transferring the collected debris into transport containers. Figure 2 illustrates painted boards being inserted into the mobile planing unit and the clean boards being extracted from the other side.

Figure 2. Self-contained MU for planing LBP from wood.

During the demonstration, efficiency enhancements were suggested and tested in order to further improve the economics of the process. Experienced equipment operators were employed to avoid upwardly skewing process costs with a learning curve that would not actually be a recurring factor in an established operation. However, the cost did include equipment use and maintenance costs in addition to the deconstruction procedures and waste disposal costs.

The three barracks buildings were deconstructed in stages, with some work being performed on all three concurrently. During deconstruction the materials were segregated according to whether they were candidates for wood recovery, non-wood recycling, or construction and demolition (C&D) debris. Wood components selected for LBP removal were denailed and stacked to be transported to the feed staging side of the MU.

The MU included a source of compressed air for the operation of pneumatic “nail kickers” that remove the nails from the lumber. Additional screening for embedded metals was also performed, but was not a prerequisite for the deleading process. To ensure the most efficient use of the MU, the crew’s goal was to supply the siding to the planer in a continuous stream from the start of operation.

Boards of similar widths were grouped together; all available boards of a given width were processed in a single run. The MU can process boards of any length, but the feedstock was also presorted by length to facilitate later sorting of the processed wood. Adjustments to machining

width and board thickness require entry to the MU. When adjustments were necessary, a short shutdown sequence was followed to prevent any fugitive dust releases. The HEPA filtration system was run during equipment shutdown to maintain the negative air pressure within the MU while adjustments were made. Adjustments typically required about 30 minutes to complete.

Permissible levels of airborne lead resulting from deconstruction and material processing activities were determined by the MBUAPCB per the California Environmental Protection Agency Air Resources Board *Risk Management Guidelines for New, Modified, and Existing Sources of Lead*. MBUAPCB counseled the contractor on the appropriate monitoring and sampling procedures required.

Previous tests have shown variations of residual lead concentrations at various depths of the recovered wood, but they are generally significantly lower than 600 ppm, the target threshold. A conservative depth (greater than 0.10 inch) was used during the demonstration to restrict lead residues on the final product to minimal levels (less than 50 ppm). Note that 1 ppm is equivalent to 1 mg/kg.

An MU operating team consists of one operator and laborer on the feed side and as many laborers as needed on the sort side to keep up with unit output. Typically the output would be sorted by length, then wrapped and banded for transportation to another site for finish milling.

As previously noted, MU continuous operation was limited to 6 hours/day because of environmental restrictions on diesel exhaust emissions from the unit's electricity generator. This would suggest a maximum daily quantity of about 9000 lf, assuming a feed rate of 25 lf/min. However, the design parameters of the MU allow for a faster feed rate; the optimum speed is determined by the feedstock species, quality, and the end-use potential of the material. A higher quality of feedstock may allow for a more aggressive feed and, as a result, increased volume of processed wood.

2.3 PREVIOUS TESTING OF THE TECHNOLOGY

The current generation of AMI Yield Pro equipment was developed for use by lumber mills and pallet recyclers to reclaim scrap wood and old pallets for reprocessing into value-added wood products. Ordinarily, lumber mill scrap and old pallets are ground up and used for fuel or low-value products such as mulch. At the time of this demonstration, AMI operated more than two dozen Yield Pro devices in commercial use.

ERDC-CERL, in a cooperative effort with the U.S. Department of Agriculture (USDA) FPL, previously completed a small-scale project using the subject wood reclamation technology. In that demonstration, the siding from two WWII-era barracks was removed and processed through the Yield Pro planer. Various ways to reuse and recycle the demolition debris from Fort Ord WWII-era wooden buildings were investigated during summer 2002. Optimal profiles for the recovered siding were considered.

More recently, the MU was also used to remove LBP from removed from WWII-era Army buildings at California State University at Monterey Bay, CA (part of which is located on the former Fort Ord). While the reclamation of wood by mechanically removing the LBP from the wood was a topic addressed in the overall focus of the earlier projects, it only focused on the

siding only and did not consider other wood materials from the buildings and the associated costs. This demonstration, by contrast, investigated all significant potential sources for reclaimed lumber available within the barracks targeted for demolition as well as total building removal and salvage costs.

2.4 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY

The principal advantages of the technology were found to be as follows:

- It is commercially availability.
- It reduces overall costs of landfilling C&D debris.
- It solves a costly pollution prevention problem for the Army and DoD.
- Technology is mobile and self-contained.
- Generated lead wastes are dry, concentrated, and easily packaged for disposal.
- Unskilled labor can be used for deconstruction, reducing labor costs.
- Lack of competitive technologies for this kind of recovery.

The limitations of the technology were found to be as follows:

- The required careful deconstruction procedures add labor costs.
- MU can process only one board at a time.
- Assessment for optimal profiles requires hands-on inspection and qualified judgment.
- Skilled labor is required to operate machinery at the inlet and outlet work stations.
- Handling of LBP shavings and scraps is regulated by mandates on hazardous waste.

3.0 DEMONSTRATION DESIGN

3.1 PERFORMANCE OBJECTIVES

The objectives are summarized in Table 1. Note that 1 ppm is equivalent to 1 mg/kg.

Table 1. Performance objectives.

Type of Performance Objective	Performance Criteria	Expected Performance	Actual Performance
Quantitative	Net cost	Less or equal to $12/sq ft of building	$12.01/sq ft not incl contractor's claim; $15.49/sq ft, incl. contractor's claim
	Time: project schedule	Remove building in no more than 6 work days	8 work days / building
	Time: productivity	Process 9000 lf of clean wood products per day	11,240 lf / day
	Quality: waste reduction/landfill diversion	Divert 60% or more from landfilling	80.30% reduction in landfill burden
	Quality: marketability of salvaged materials	Market 50% or more of salvageable wood	71.60% of wood sold
	Safety: accidents	Zero reportable accidents	1 lost time accident discovered by ERDC-CERL
	Safety: airborne lead dust	Prevent airborne lead concentrations approaching 30 ppm within 100 ft of MU	Nondetectable levels outside MU; 30 ppm within unit
	Safety: lead concentration in processed wood products	Limit residual lead in cleaned wood products to less than 600 ppm	<6 – 34 mg / kg detected at wood surface
Qualitative	Product quality: marketability	Interest by local mills & lumber dealers	Lukewarm interest because of low volume. Interest by dealers if greater quantities are available
	Safety: LBP handling	Comply w/all applicable regulations; no NOVs*	No violations
	Regulatory guidance:	Develop recommendations for USEPA*/DoD/others for LBP-coated materials' handling	Results of characterization are being incorporated into Army Public Works Technical bulletin

*NOV = notice of violation
**USEPA = U.S. Environmental Protection Agency

The equipment and processing were set up and operated in the same conditions, manner, and scale as would be expected for similar real-world projects at military installations. Experienced equipment operators were used to minimize any learning curve that might negatively skew the cost data. The deconstruction and materials-handling operations were documented. During operations, enhancements were explored to maximize procedural and equipment efficiencies, from board removal techniques to the steps necessary for making high-value finished products.

An independent cost/benefit analysis addressing equipment use, maintenance costs, deconstruction procedures, and waste disposal was performed to verify the recorded results.

3.2 SELECTION OF TEST SITE AND FACILITIES

The prime location for this demonstration was Camp Roberts, a large California Army National Guard installation in west-central California. This site was ideal because it has hundreds of vacant WWII-era buildings on the property that must eventually be removed. All of them have LBP-coated materials. There is ample room for a demonstration.

3.3 TEST SITE/FACILITY HISTORY AND CHARACTERISTICS

Congress authorized funds for the purchase of land and building of training sites in 1940. The 42,784 acres that compose Camp Roberts have served as a training installation and as an out-processing center for hundreds of thousands of soldiers during WWII, the Korean War, and the Vietnam War. At its peak of activity, Camp Roberts ranked among the world's largest military training centers. Camp Roberts was officially closed by the Army as a training installation in April 1970, and on April 2, 1971, it was reopened by the California Army National Guard, under a license from the Army, as a Reserve Component Training Center. Today the mission of Camp Roberts is to facilitate the training, mobilization, and security of the National Guard, Army Reserve, and active component units in support of federal, state, and community missions.

Camp Roberts was selected as the demonstration site because there was a high degree of support for the project and the installation has many WWII-era barracks that are ready for removal. Because the excess barracks are unoccupied and out of the way, the work could be performed without interrupting daily camp operations. Also, the contractor selected for removing the LBP from the salvaged boards is located near the site.

Another reason for selecting Camp Roberts is that the installation experienced problems in disposing of lead-contaminated wood during previous building removal activities, so a successful demonstration would concurrently solve a pre-existing problem. The Camp Roberts DPW had recent cost data for those building-removal activities, and that information was highly beneficial in performing cost analyses for comparing the various deconstruction options and validating the benefits of the technology being demonstrated. There are between 600 and 700 WWII-era wooden buildings that will need to be removed because of future new construction that is expected.

3.4 PHYSICAL SETUP AND OPERATION

The contractors were responsible for selecting a suitable location for the MU, which consisted of level ground measuring approximately 150 x 150 ft. The location selected was near the center of the three-building group. It was out of the way of the deconstruction and material handling activities, but not so far away that transporting materials to the MU was difficult or time-consuming. A short checklist of procedures preceded start-up. The MU was moved as needed for optimal processing logistics. Upon arrival of the MU to the work site, start-up typically takes less than 2 hours.

Siding and interior boards removed from the buildings were deposited in stacks between the barracks and the mobile planing unit. A denailing station was set up between the boards and the mobile planing unit, consisting of polyethylene sheeting on the ground (to capture nails and painted wood debris) and saw horses. An air compressor powered the Nail Kicker denailing tool. Boards with nails were handed to the denailing station, denailed, and stacked. The denailed boards were then carried to the opposite side of the mobile planing unit and stacked in preparation for planing. Ideally, all preparations for the planing should have taken place on the "feed" side of the mobile planing unit. Or, in this case, the "feed" side of the mobile planing unit should have been oriented toward the buildings being deconstructed.

One laborer and the machine operator fed the painted boards into the mobile planing unit, and two laborers received the clean boards at the "discharge" side of the mobile planing unit. The boards were stacked and banded for future transportation.

All planing was completed within two working days, each day consisting of no more than 6 hours of the MU's operation. This limit of 6 hours per day limit was established by the MBUAPCD in order to limit exhaust emissions from the diesel generator. The limit had nothing to do with the planing operation itself.

The LBP residue was collected in plastic bags and deposited with the LBP-coated wood debris. Site cleanup consisted of raking and sweeping some wood chips and splinters that escaped the discharge chute.

3.5 SAMPLING AND MONITORING PROCEDURES

The potential value of salvaged and processed wood materials was performed by USDA. FPL personnel obtained pricing data from material exchanges, industry directories, personal market contacts, and six local mills specializing in salvaged or antique millwork.

Data on productivity and application of resources was compiled and reported by AGSC. AGSC provided summaries of tasks and labor-hour requirements. AGSC also provided daily reports, from which labor and equipment use could be collaborated. ERDC-CERL and the National Defense Center for Environmental Excellence (NDCEE) conducted field observations while on site. AGSC provided the unit costs for labor, equipment, materials, and other resources, upon which ERDC-CERL could calculate actual costs.

Ambient and personal air monitoring also were conducted during the reprocessing of the wood siding through the MU according to OSHA 29 CFR 1926.62. Eight ambient air samples were collected both downwind and upwind of the MU, including one within the MU.

ERDC-CERL collected samples of redwood and Douglas fir siding to evaluate the depth and amount of any residual lead present on the wood surface after the planing operation. Both Douglas fir and redwood were tested for total lead by Forensic Analytical Laboratories, Haywood, CA, using USEPA Method 3050B/7420. Three samples each of Douglas fir and redwood siding were tested with the paint film intact, and again after shaving away 1/16-, 1/8-, 3/16-, and 1/4-inch of wood. The equipment was cleaned after each planing pass to avoid cross-contamination.

Actual quantities of salvaged and planed wood materials were counted by ERDC-CERL personnel. Debris quantities were compiled using AGSC's waste disposal invoices, manifests, and landfill tickets.

3.6 ANALYTICAL PROCEDURES

The air samples were tested by Forensic Analytical using National Institute for Industrial and Occupational Health (NIOSH) Method 7105. Air samples were collected from personnel conducting reprocessing activities. Six personal air samples were collected and transported to Forensic Analytical for testing using NIOSH Method 7082. The demonstration was continuously monitored in order to avoid exceeding the CalOSHA 3-month limit.

Both Douglas fir and redwood were tested for total lead by Forensic Analytical using USEPA Method 3050B/7420. In order to determine the presence of residual lead on the machined wood profiles, lead testing was performed according to ASTM E1278-03, *Standard Practice for Collection of Settled Dust Samples Using Wipe Sampling Methods for Subsequent Lead Determination.* The original siding, the manufactured profiles, and the machinery were all monitored.

Debris characterization was performed by National Analytical Laboratories, Inc. (NAL) per USEPA SW846 (TLLC) & California Waste Extraction Test (Cal WET), as required by Title 22, Division 4.5, Chapter 11, Article 3, section 66261.24 of the California Code of Regulations (CCR).

4.0 PERFORMANCE ASSESSMENT

4.1 PERFORMANCE DATA

AGSC compiled the project performance data. ERDC-CERL personnel were present on site for 9 of the 15 working days to monitor, record, and collect sample data independently of the contractor. ERDC-CERL personnel also audited AGSC's salvage data to verify its accuracy. The NDCEE was present on site to record deconstruction activities, sequences, and results. They assisted ERDC-CERL personnel in gathering data on salvaged material descriptions and characteristics. The ERDC-CERL and FPL personnel monitored the wood processing and provided an independent assessment of the wood product's value and marketability.

The performance data collected during the demonstration are listed in Table 2.

Table 2. Project performance data.

Performance Parameter	Expected Performance	Performance Confirmation Method	Demonstrated Performance	Performance Measure Met
Quantitative Measures				
Net cost	Net cost of building removal is less than $12/sf	Labor, equipment, & materials costs were reported to ERDC-CERL by AGSC. Payroll & expenditures were monitored by USACE Mobile District Quality Assurance (QA) Representative.	14,160 sf of building removed at $219,309, or $15.49/sf	No
Time: project schedule	Process: 6 working days per building	Daily reports were submitted by AGSC describing schedule and progress. Schedule & progress was documented per field observations by ERDC-CERL & NDCEE personnel.	3 buildings were deconstructed in 24 work days = 8 work days/building	No
Time: productivity	Process at least 9000 lf of clean wood product per day	Daily reports were submitted to ERDC-CERL by AGSC describing schedule and progress. Schedule & progress was documented per field observations by ERDC-CERL & NDCEE personnel.	22,480 lf of siding was processed in two 6-hour work days = 11,240 lf/day	Yes
Quality: waste reduction, landfill diversion	60% reduction landfill burden	Bin rental, hauling, & tipping receipts were compiled by AGSC & supplied to ERDC-CERL. ERDC-CERL calculated landfill disposal and diverted quantities.	80.3% reduction of landfill burden	Yes

Table 2. Project performance data. (continued)

Performance Parameter	Expected Performance	Performance Confirmation Method	Demonstrated Performance	Performance Measure Met
Quality: marketability of salvaged materials	Market 50% of recoverable wood material into higher value products	Processed wood materials were counted on site by the MU counter, then verified by piece count by ERDC-CERL personnel. Salvaged wood materials were calculated per ERDC-CERL quantity takeoff, and verified by on-site count by ERDC-CERL personnel.	8.3% of recoverable wood was processed into higher value products; 71.6% of all wood was reused.	Yes
Safety: accidents	Zero reportable accidents	Health and safety program (HASP) reports	No reported or lost time accidents	No
Safety: airborne lead dust	Prevent airborne lead concentrations from approaching 30 ppm threshold within 100 ft of MU	Ambient air samples were taken per NIOSH 7082, 8 outside & 1 inside the trailer. Cartridges were analyzed by NAL. 6 personal air samples were taken per NIOSH 7082. Cartridges were analyzed by NAL.	All samples outside MU resulted in non-detectable levels of lead. 30ppm detected within the MU.	Yes
Safety: lead concentration in processed product	Produce clean wood products with no greater total lead content on the surface than the 600 ppm allowable for consumer-available paint	Surfaces of intact paint layer, then at depth of 1/16, 1/8, 3/16, & 1/4-inch depths were tested per USEPA Method 3050B/7420.	Residual lead measured at <6 mg/kg to 34 mg/kg	Yes
Qualitative Measures				
Product quality: marketability	Real-world market demand for old-growth, high grade wood products	Market survey conducted by FPL consisting of Internet search, lumber dealer & broker contacts, & discussions with five local mills.	Low volume of available finished wood reduced final sale prices. Inquiries have been received by lumber dealer about availability of greater volume.	Yes
Safety: LBP handling	Perform all hazardous waste disposal tasks within regulatory provisions	LBP-contaminated debris handling & disposal monitored per site observations by USACE Mobile District QA Representative. Debris characterization performed by NAL per USEPA SW846 (TLLC) & Cal WET., as required by Title 22, Division 4.5, Chapter 11, Article 3, section 66261.24 of the CCRs. Waste manifests were written by Camp Roberts Environmental Division personnel.	All hazardous materials were handled per regulatory provisions.	Yes
Regulatory guidance	No existing measure of acceptable Pb in recovered wood	N/A	Results of Pb characterization are being incorporated into Army Public Works Technical Bulletin.	N/A

4.2 PERFORMANCE CRITERIA

The Environmental Security Technology Certification Program (ESTCP) performance criteria addressed process effectiveness, efficiency, and safety. The first two categories of criteria were measured in terms of time, cost, and quality (Table 3). Criteria for those categories were defined and characterized in terms of the project objectives (Section 3.1).

Table 3. Performance criteria.

Performance Category	Performance Criterion	Performance Measure Met
Quantitative Measures		
Net cost	Net cost of building removal is less than \$12/sf	No
Time: project schedule	Process: 6 working days per building	No
Time: productivity	Process at least 9000 lf of clean wood product per day	Yes
Quality: waste reduction and landfill diversion	60% reduction in landfill burden	Yes
Quality: marketability of salvaged materials	Market 50% of recoverable wood material into higher value products	Yes
Safety: accidents	Zero reportable accidents	No
Safety: airborne lead dust	Prevent airborne lead concentrations from approaching 30 ppm threshold within 100 ft of MU	Yes
Safety: lead concentration in processed products	Produce clean wood products with no greater total lead content on the surface than the 600 ppm allowable for consumer available paint	Yes
Qualitative Measures		
Product quality and marketability	Real-world market demand for old-growth, high-grade wood products	Yes
Safety: LBP handling	Perform all hazardous waste disposal tasks within regulatory provisions	Yes
Regulatory guidance	No existing measure of acceptable Pb in recovered wood	N/A

4.3 DATA ASSESSMENT

4.3.1 Schedule Assessment

The complete deconstruction, materials salvage, and processing cycle required approximately 8 days per building, which exceeded the intended schedule by 3 days per building. There was no time pressure by subsequent property developers or construction contractors, so the demonstration schedule as executed created no adverse consequences for Camp Roberts.

AGCS was inexperienced in deconstructing buildings. The company's unit productivity was not unreasonably low, but ERDC-CERL experience with experienced deconstruction contractors has shown that this same type of task can be completed in significantly less time than in the current project. For example, a deconstruction contractor at Fort Lewis, WA, is removing barracks from their foundations at a rate of one building per day.

Remilling the siding material was a minor component in the overall project schedule, requiring only 5 days to mobilize, set up, process the materials, and demobilize the equipment. AGSC

denailed the siding boards in 7 days. About 20,000 lf of siding was run through the MU in 2 days, concurrent with the denailing, and stacked ready for shipping. As previously noted, the MU was permitted to run only 6 hours/day due to diesel emission concerns. In total, seven 8-hour workdays were needed to complete this task. A processing rate of 10,000 lf per 6-hour workday, or 1667 lf/hour, was achieved.

4.3.2 Quality Assessment

The quality of the wood materials removed from the barracks buildings was high (Figure 3). There were very few knots or other defects. Very little wood deterioration or damage was observed, meaning that little of the salvaged wood was lost to reuse. All the deleaded material was transported to Calaveritas Mill (San Andreas, CA). Calaveritas Mill processed a small portion of this material into both paneling and flooring (Figure 4) to advertise and further demonstrate the recovery potential of millwork from reclaimed siding.

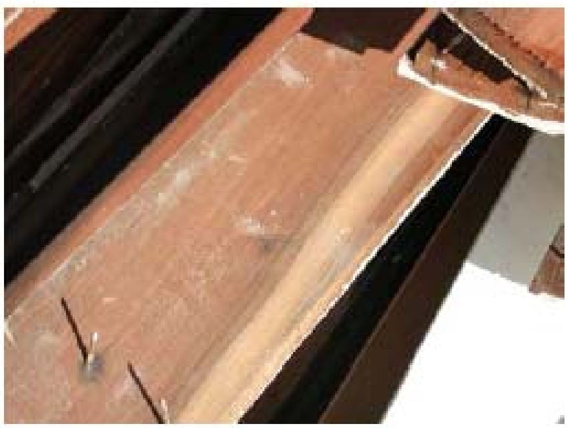

Figure 3. High-quality redwood before nail removal.

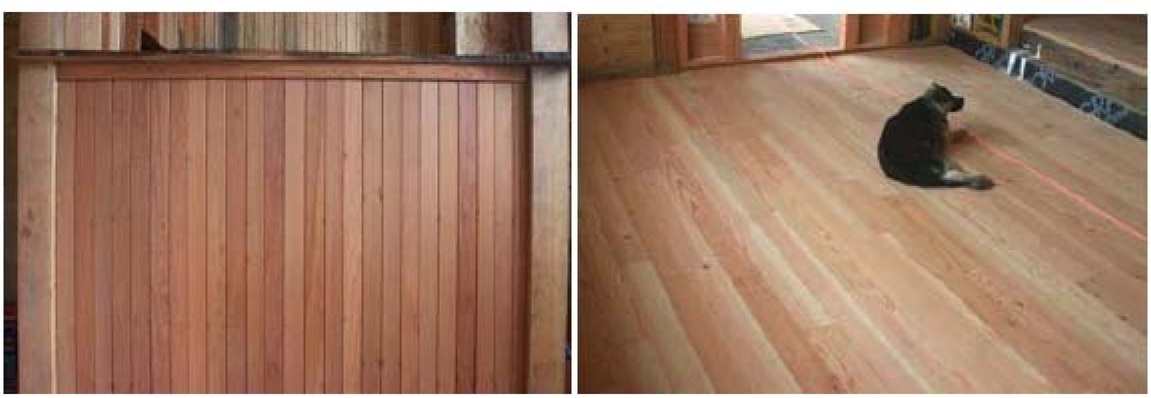

Figure 4. Redwood paneling (left) and Douglas fir tongue and groove (T&G) flooring (right) milled from a portion of salvaged siding from the Camp Roberts.

The amount of heartwood and sapwood is an important quality characteristic in the redwood species, with a higher content of heartwood more desirable. "All heart"—100% heartwood content—is the highest grade. Most of the redwood pieces were heartwood. There were

relatively few knots observed; more than 94% of the redwood was clear, and more than 58% of the Douglas fir was clear. Material losses due to end splits or other conditions requiring end-trimming accounted for only 4.7% of the total linear footage. Little decay from in-service use was found in the blanks, but drilled utility holes were occasionally found. Some observed wood discoloration was probably caused by nail corrosion.

The mobile planing unit did produce some imperfect wood blanks. Some of the samples had residual LBP remaining after the planing process. Another common machining problem observed was the creation of undersized blanks. Some pieces were narrower than the target width, and some thinner. One cause for the problem may have been tool dulling combined with an excessive feed speed during deleading. However, this problem is not considered serious enough to consider the pieces unacceptable for remanufacture purposes. It amounts to a processing problem that could be addressed through changes in technique in order to provide better dimensional uniformity and control over the processed feedstock.

Based on quantity takeoffs, ERDC-CERL estimated the total weight of three buildings to be 407 tons. Actual quantities in the standing buildings were verified on site by ERDC-CERL personnel. The actual weight of materials hauled for landfill disposal was recorded at 80 tons. All other materials were salvaged, recycled, or processed. Therefore, 327 tons of material — 88.3% of the buildings' mass — was diverted from landfill disposal.

4.3.3 Safety Assessment

This demonstration verifies that it is not unduly difficult to set up effective control measures in the mobile planer unit that prevent health hazards related to LBP. No significant amounts of lead, either in terms of personal exposure or ambient levels, were detected in the course of air monitoring. The only airborne lead concentration that approached the OSHA Permissible Exposure Limit (PEL) was inside the self-contained MU, and work site procedures prohibited entry by anyone without the appropriate respiration protection.

Personal and ambient airborne lead monitoring also verified that deconstruction activities do not create a safety hazard. Personal air monitoring showed airborne lead concentrations to be essentially nondetectable. Good housekeeping practices, the use of the protective Tyvek suit, and frequent hand washing are judged to be effective against the transfer of lead dust on workers to off-site locations such as home.

Residual lead levels on the planed wood surfaces were verified to be benign. After the paint layer and 1/16 inch. of the painted wood surface was removed, the concentration of lead in the wood measured less than 30 ppm (30 mg/kg), which is far below the 600 ppm (600 mg/kg) allowed for consumer-grade paint that might come into mouth contact with infants.

Overall, based on the results of this demonstration, it may be concluded that deconstruction activities should not present any hazard that is not already addressed in OSHA Construction Safety Standards. However, considering that there were two incidents in which workers stepped on nails during this demonstration, it is advisable for project managers to verify that deconstruction workers are current in their tetanus immunizations and to require that shoes with steel insoles be worn at all times on the work site.

AGSC developed a HASP to describe hazards that would be present during the project and measures to mitigate hazard and protect workers. Issues typically of concern on a deconstruction site include hazard communication, LBP protection, fall protection, ladder safety, personal protective equipment (PPE), equipment safety and operation, daily safety meetings, and others. As asbestos abatement was included within the contract scope, asbestos abatement and safety was included in the HASP even though it had no direct impact on the deconstruction and LBP removal tasks.

4.4 TECHNOLOGY COMPARISON

There is no standard existing technology or practice for deconstructing WWII-era buildings, salvaging lumber materials, and processing LBP-contaminated wood into marketable millwork products. All material salvage, waste diversion, and value accrued through this demonstration are favorable compared to the existing practice of mechanical demolition and landfill disposal.

5.0 COST ASSESSMENT

5.1 COST REPORTING

The major cost factors for this ESTCP demonstration are described in Table 4. These represent activities and costs directly relevant to demonstrating the mobile planing unit technology. Other costs were incurred during this demonstration (safety management, asbestos abatement, foundation removal, mobilization and demobilization, sanitary facilities, and others similar), although they would have been incurred for conventional demolition as well, and are extraneous to the demonstrated technology.

Table 4. Costs by category (thousands of dollars).
( ) = cost savings or avoidance

Direct Environmental Activity and Process Costs				Indirect Environmental Activity Costs		Other Costs		Total
Start-Up		Operation and Maintenance						
MU permitting	0.998	WWD planer rental	1.50	PPE & lead containment materials	0.13			
Siding board removal	73.60	MU mobilization	0.40	Air monitoring	8.29			
Building disassembly	15.70	Board planing	2.82					
Lumber salvage & resale (1)	(26.70)	Planed wood resale (1)	(11.9)0					
Clean wood recycling (2)	(16.60)	LBP residue disposal (4)	11.30					
Siding & board denailing	13.60	MU demobilization	0.40					
LBP debris disposal (3)	47.86							
Totals	108.46		4.52		8.42			121.40

Notes:
(1) Includes resale value plus disposal cost avoidance
(2) Includes disposal cost avoidance
(3) Includes all debris materials except LBP residue from the MU
(4) Includes LBP residue from the MU only

One can see that most of the cost involved removing the siding boards and preparing them for running through the mobile planing unit. The actual planing operation itself was a relatively minor cost.

5.2 COST ANALYSIS

A large portion of the cost for this demonstration involved tasks not ordinarily performed during demolition but necessary to reclaim the wood and prepare it for remilling. Removing the siding and roughly half the interior wall finish boards was the largest task in this category, costing AGSC $73,589. This work would not have been necessary in a conventional demolition project. Disassembly of the framing lumber cost AGSC $15,700, which is roughly $10,000 more than it

would have cost to crush the structures with a track hoe and load the debris into a truck for disposal. Altogether, AGSC spent approximately $83,600 more to disassemble these buildings than had they mechanically demolished them.

Salvaging the clean (i.e., unpainted) lumber from the deconstructed barracks served to reduce the project landfilling requirements as compared with conventional practices. Had 33,000 board foot (bf) (which is 45.4 tons, or 378 cuyd) of framing and sheathing lumber been disposed of as nonhazardous C&D debris, the cost would have been $23,196. Adding the $3600 purchase price for this lumber, salvaging and selling the framing lumber saved more than $26,700 compared with landfilling it. Recycling the uncontaminated wood scrap also reduced the project disposal cost compared with conventional C&D landfill disposal. AGSC paid $46 per cuyd less to take uncontaminated wood scrap to recycling, so the company saved $16,563 as compared with the cost of landfilling that material as C&D debris.

There are two general areas of opportunity to improve efficiency and reduce costs in a deconstruction and reclamation project similar to this demonstration:

- Paint-removal milling operations
- Deconstruction operations.

In this project, the MU planer was configured to remove LBP from boards up to 6-inches wide. Although the equipment owner claimed that the planer was adjustable to accommodate other board widths, this capability was not demonstrated by the work crew because the method for doing so was not self-evident. Because much of the salvaged wood was nominally 8-inches wide, there was no way to plane all the LBP off the boards without feeding it through the MU twice. In this case, 2-inches of board width were sawed (i.e., ripped) away during the first pass through the planer, fed through separately. These extra steps in the planing process were given as a reason that the contractor opted to landfill most of the 8-inches salvaged boards instead of reclaiming them for marketing purposes. If the planing tool had been readily field-adjustable to handle the widest boards at the deconstruction site, milling efficiency for those boards could have increased by at least 50%, thereby removing the contractor's stated disincentive for reclaiming significant portions of the salvaged lumber.

Although the MU may be considered an enabling technology that makes it feasible to dramatically improve the economics and sustainability of building removal, successful deconstruction and reclamation work nevertheless depends on the efficient application of labor. AGSC's total building removal rate of 8.5 sf of building/labor hour has been significantly exceeded in the field by other contactors working on similar projects at other installations. For example, as noted previously, a deconstruction contractor at Fort Lewis, WA, has achieved a building removal rate of more than 30 sf of building/labor hour with expert use of mechanical equipment, a result that included the salvage of custom-grade Douglas fir siding for resale. Also, in a similar project conducted at Fort Chaffee, AR, the contractor removed the siding at a rate of more 80 sf of siding/labor hour, approximately 10 times the productivity rate (8.35 sf of siding/labor hour) achieved by AGSC. These competing productivity results show that a building removal contractor with sufficient expertise and motivation for profit could dramatically improve the economic results of a comparable project as compared with the results returned in this demonstration.

5.3 COST COMPARISON

The approach to calculating a true cost of the technology would be based on estimating what the costs and savings would be if AGSC had actually processed the other LBP contaminated wood. While this was not demonstrated directly it is nevertheless less arbitrary than simply subtracting the claim costs and comparing the remaining actual cost with the estimated cost for conventional demolition and landfill disposal. Costs relating directly to the use of the mobile planing technology are the cost to denail boards prior to being run through the MU, the cost to plane boards through the MU, and the cost to dispose of LBP residue. Costs savings directly related to the use of the mobile planing technology are the reduced quantity and cost of material to be deposited in a RCRA certified landfill and the resale value of planed lumber materials.

Table 5 compares three cost scenarios: (1) the actual demonstration costs, (2) the estimated cost of conventional demolition and landfill disposal with no consideration of cleaning and salvaging LBP-coated materials, and (3) deconstruction and salvage, assuming AGSC had actually planed and salvaged all the LBP-coated wood required of them. Again, only the costs directly relevant to the MU are shown. All costs that would have been incurred regardless of the building removal method are omitted for clarity.

Table 5. Costs Comparison.

( ) = cost savings or avoidance

	Demonstration		Conventional Demolition		Deconstruction & Salvage
MU mobilization	$400		$0		$400
Mobile planing unit permit	$998		$0		$998
Air monitoring	$8300		$0		$8300
PPE & lead containment mat’l	$125		$0		$125
Siding & board removal	$73,600		$0		$73,600
Building demolition or disassembly	$15,700		$16,500		$15,700
Lumber salvage/resale	$ (3600)		$0		$ (3600)
Salvaged lumber disposal avoidance	$ (23,100)		$0		$ (23,100)
Recycled wood disposal avoidance	$ (16,600)		$0		$ (16,600)
Siding & board denailing	$13,600		$0		$13,600
WWD MU rental	$1500		$0		$1500
Siding & board planing	$2824		$0		$6500
Planed wood resale	$ (600)		$0		$ (5200)
LBP wood disposal	$59,200		$150,000 (1)		$21,100
MU demobilization	$400		$0		$400
Contractor claim	$47,563		$0		$0
TOTAL	**$180,130**		**$166,500**		**$93,723**

Note:
(1) Includes all building debris. Concrete would be disposed of at a nonhazardous rate. Commingled building debris from Camp Roberts buildings exceeds the toxicity characteristic leaching procedure and Cal WET thresholds and would be disposed of at hazardous waste rates.

While not directly related to the mobile planing unit technology itself, this demonstration created additional benefits by reducing local landfill burdens by 327 tons and providing sustainable substitutes for more than 33,000 bf of virgin lumber, more than 60 tons of quarried aggregate,

and more than 10 tons of recycled metals. If concrete rubble and scrap metals could have been deposited with the Camp Roberts recycling programs, an additional $17,754 in hauling cost could have been saved. This figure does not include any salvage value for the concrete or metals, or cost avoidance arising from the use of recycled concrete aggregate in place of quarried aggregate.

5.3.1 Life-Cycle Costs

In the case of Camp Roberts, the Army does not incur landfill life-cycle costs directly because it pays for disposal of debris off-post. Ideally, the off-post waste disposal facility funds its landfill operation, management, monitoring, closure, and long-term monitoring out of its tipping fees. If, however, an installation owns and operates its own landfill, as do most major troop installations, then the Army directly bears the life-cycle cost of landfilling C&D waste.

Based on a survey of three installations, the Army life-cycle cost of landfill management is $38 – $50/ton (net present value). Every ton of C&D debris not deposited in a landfill can be inferred to reduce Army waste management costs by an amount falling within that range. Furthermore, because landfill expansion on installations is no longer permitted, existing on-post landfill capacity is a resource that cannot be replaced. The total amount of materials diverted from landfills by this demonstration was 327 tons. If Camp Roberts operated its own landfill, then using a conservative life-cycle cost of $38/ton, an equivalent life-cycle savings would amount to $12,426 (net present value) for this demonstration.

Life-cycle expenses encompass more than the direct cost of landfill management. Other life-cycle environmental stressors are produced by C&D waste, although the adverse effects have not yet been quantified in financially. The USEPA Waste Reduction Model (WARM) analyzes the life-cycle effects of alternative waste disposal scenarios. The output is quantified in terms of metric tons of carbon equivalent (MTCE), metric tons of carbon dioxide equivalent ($MTCO_2E$), and energy use in millions of BTUs. Two scenarios were run to identify both the life-cycle environmental effects of landfilling all building debris and diverting materials from landfills (as recorded for this demonstration). Table 6 shows the baseline scenario (landfill disposal of all materials) and an alternative disposal strategy (source reduction through reuse, recycling, and disposal).

Table 6. WARM results for demonstration waste diversion.

Baseline Scenario: Landfill All C&D Debris					
Material	*Generated*	*Recycled*	*Landfilled*	*Combusted*	*Composted*
Concrete	190 tons	0 tons	190 tons	0 tons	0 tons
Lumber	98 tons	0 tons	98 tons	0 tons	0 tons
Metals	3 tons	0 tons	3 tons	0 tons	0 tons
Alternative Scenario: ESTCP Demonstration Waste Diversion					
Material	*Generated*	*Recycled*	*Landfilled*	*Combusted*	*Composted*
Concrete	190 tons	190 tons	0 tons	0 tons	0 tons
Lumber	45 tons	27 tons	26 tons	0 tons	0 tons
Metals	3 tons	3 tons	0 tons	0 tons	0 tons

Reducing the quantities of waste generated through salvage for reuse and recycling, WARM calculated the life-cycle effects of this demonstration would be as follows:

- Reduction of 81 MTCE
- Reduction of 149 $MTCO_2E$
- Reduction of 546,000 BTUs energy use, which is equivalent to 94 barrels of oil, 4367 gallons of gasoline, or removing eight passenger cars from the roadway every year.

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6.0 IMPLEMENTATION ISSUES

6.1 COST OBSERVATIONS

The actual cost of denailing boards and using the mobile planing unit to produce feedstock for further milling is quite modest relative to the total building removal cost. This task accounted for approximately 12% of the total project labor requirement. Removing the boards from the buildings was a major cost factor for the project. This task accounted for approximately 44% of the total labor for the project, and 60% of the labor applied to deconstruction and salvage activities. Overall costs depend on the efficiency of the contractor in performing these tasks, and there is significant room for improvement in productivity achieved in this demonstration. ERDC-CERL has observed deconstruction projects on other Army installations where the overall rate of building removal was approximately four times the rate achieved by AGSC, and the rate of siding removal was approximately 10 times the rate achieved by AGSC.

The resale value of the unpainted framing and sheathing lumber and the planed boards was relatively modest, only $4200. The major cost savings was achieved by virtue of diverting both hazardous and nonhazardous debris. By not landfilling salvaged lumber, recycled wood scrap, and the LBP-coated boards processed through the mobile planing unit, more than $90,000 was saved, Had AGSC processed all the lumber materials they should have, this savings would be greater.

6.2 PERFORMANCE OBSERVATIONS

The mobile planing unit performed well. The quality of the redwood and Douglas fir materials removed from the buildings was quite good. Little loss was experienced due to damage or deterioration in the boards. The mobile planing unit produced the blanks as expected. Irregularities were experienced in some of the end product, specifically “off-spec” width and/or thickness, and visible LBP residue. However, the incidence of these irregularities was low, and the probable cause was attempting to force boards through the machine too rapidly.

The MU’s production rate is not the governing factor for the deconstruction or material processing activities. It takes much longer to prepare the boards for planing than the planing operation itself.

Airborne lead dust was not problematic during the deconstruction or handling of the LBP-coated wood products. Airborne lead dust was successfully controlled by the mobile planing unit. The only concentration approaching the OSHA PEL occurred within the trailer itself, and no one without full PPE was allowed in the trailer. The only emission of any consequence was the generator’s diesel exhaust, which limited operating time to 6 hours per day.

Residual lead on the planed boards was not problematic. The remaining concentration of lead was quite low, far below threshold limits for lead on surfaces established by USEPA and the Department of Housing and Urban Development (HUD).

6.3 SCALE-UP

As the WWD mobile planing unit is the only machine of its type in existence, applying it throughout the Defense services will be difficult. Building removal requirements will dictate demolition schedules, not the availability of the equipment. If installations can remove siding and other salvageable painted lumber during demolition and hold it without violating local dumping or stockpiling regulations, the mobile planing unit could be brought to the installation and process a much larger stock of materials than the demonstration in a relatively short period of time. Other schedule, contract, and materials ownership issues would have to be resolved.

The quantity of materials produced during the demonstration did not attract much attention from the local salvaged and antique millwork industry. These businesses are used to dealing with quantities of magnitude greater than the demonstration volume. If, for example, the Redwood and Douglas fir siding could be removed from all vacant buildings at Camp Roberts, or Fort Ord (or both), there should be a significant interest in these materials and the resale value should be much higher. Unfortunately, building removal processes are driven by different influences.

6.4 OTHER SIGNIFICANT OBSERVATIONS

As of December 2007, the owner of the MU retired from the building materials recovery industry in California, and no plans had been made to further develop or replicate the unit. The machinery was last used at Fort Chaffee, AR, and remained there at the time this was written.[4]

While the WWD MU is not widely available for wood reclamation at this time, other mechanical paint removal processes are usable for the purpose. ERDC-CERL and the USDA FPL processed Douglas fir siding from Fort Ord using conventional wood working equipment with a HEPA filter evacuation system.[5] Trial lots of T&G flooring, V-groove siding, and bevel siding were produced. A deconstruction contractor at Fort Lewis, WA, removed Douglas fir T&G siding from barracks and sold it to a local mill. The mill removed the LBP but did not reshape the boards. That cleaned wood was then resold for incorporation into the adaptive reuse of a historic building in a Seattle-area community.

6.5 LESSONS LEARNED

Due to the lack of industry-wide inventory and marketing data for reclaimed wood products, it is currently difficult to project the economic value of such material to its owner. The quality of wood originally used in the subject barracks was good. A greater percentage of redwood was available in the reclaimed stock of wood than first estimated, and it appears to have high value and good commercial potential. Eight-hundred sf of reclaimed redwood was used in the design and construction of a “green” modular home.

The thickness of the blank stock produced by the MU, 5/8 inch, must be considered a limitation of the technology because it is not an industry-standard millwork thickness. Wood reclaimed through this deconstruction/reclamation process cannot be used for any standard millwork profile

[4] In January 2008, while being used in a private venture for materials recovery, the MU was destroyed by a wind-driven fire that burned down 150 barracks at the former Army installation.
[5] Falk et al., 2006

that exceeds a thickness of 5/8 inch. This limitation could restrict the scope of market development for reclaimed wood products remilled from deconstructed wood military buildings, but it does not pose a critical obstacle to profitable large-scale adoption of the technology by motivated entrepreneurs with applicable technical and marketing expertise.

Army building removal projects using the methodology described here should not overlook the positive economic and sustainability impacts of recycling the other valuable raw materials that are available for reclamation in a deconstruction project. The efficient reclamation and recycling of steel, copper, and concrete could significantly help to offset project costs or provide additional revenue streams for the installation or building removal contractor.

The utility of mobile planing technology would significantly improve if it were field-adjustable to handle a wider variety of feedstock widths. The MU worked well and efficiently on the salvaged 6-inch by 1-inch. (nominal) siding boards in part because the cutting blades and heads were configured compatibly for feedstock of those dimensions. However, because the blades and heads were not readily adjustable to remove paint from the entire surface of wider stock in one pass, the 8-inch boards required two planing operations combined with a sawing operation (see Section 5.2, Cost Analysis). This modified procedure significantly reduced the efficiency of milling those boards, thus leading the contractor to incorrectly assume it would be more economical to dispose of the wider LBP-contaminated boards. For the best results in terms of economics and sustainability, Army users of this technology should favor planing devices that are field-adjustable to accommodate all of the standard stock sizes likely to be found in WWII-era temporary wood construction.

The visible LBP traces found on many processed boards (see Section 6.2) were determined attributable to feeding some of the wood into the planer too rapidly, causing minor recontamination of the planed wood from residues adhering to the outer edge of the cutter blades. This cross-contamination problem is not inherent to wood planing technology, however, and is avoidable through appropriate operator training and experience with the device.

The MU is an innovative tool that makes it feasible to safely and efficiently reclaim seasoned wood previously coated with LBP. However, the tool itself is part of an integrated building removal technology that presupposes the application of safe and cost-effective deconstruction and materials reclamation techniques. In order to achieve the goals of sustainability and economy, the customer and the contractor must share a clear understanding of the building removal objectives and develop a well-coordinated work plan.

In future sustainable building removal projects, the Army contracting activity should solicit for motivated bidders with experience and capabilities in the areas of building deconstruction, materials reclamation, and working with specialty millwork markets. In this demonstration, the contractor did not provide the expected level of economic performance in its actual deconstruction, salvage, and paint-removal field operations even though the firm was highly qualified to perform conventional C&D work. The profitability of a deconstruction and reclamation project depends in significant part on the contractor's expertise in building disassembly, reclamation and waste handling judgment, and efficient remilling workflows. The scope of work should include explicit language about the Army's building removal, waste

management, and project sustainability requirements but should avoid language that inhibits a qualified contractor's independent judgments about reclaimed materials of marginal economic value.

6.6 END-USER ISSUES

Standard practice for the removal of WWII-era wood buildings on Army properties is to contract for demolition services. The contract may include demolition services only, which is more typical of a DPW or Public Works Business Center (PWBC) activity, or may include demolition as one item within a construction project, which is more typical of a Corps District. Rarely would the Army perform demolition services with in-house resources.

Assistant Chief of Staff for Installation Management (ACSIM) (DAIM-FD) Policy Memorandum (06 February 2006, revised 11 July 2006) requires a minimum of 50% (by weight) diversion of nonhazardous waste from landfills. Note that in all states except California, buildings with LBP-coated materials would not necessarily be characterized as hazardous in a conventional demolition scenario and therefore would fall under the ACSIM requirement. If the concentration of lead in exterior paint is high enough, the exterior siding itself may be characterized as hazardous.

In deconstruction projects similar to this demonstration, the user of the mobile planing technology will not typically be the Army but the contractor selected to remove the buildings for the Army. The Army will benefit from the waste diversion performance because diversion is required by the DoD Measure of Merit and the ACSIM Policy on C&D debris management.

Where an installation operates a C&D landfill on-post, the installation's solid waste management authority will be the primary stakeholder in C&D waste reduction. Because opening new landfill cells or expanding existing ones is no longer permitted, decreasing landfill disposal volumes will reduce the consumption rate of available capacity and prolong the service life of the landfill.

Where the installation does not operate a C&D landfill on-post C&D waste reduction will be the responsibility of local or regional solid waste management authorities, specifically the recycling and waste reduction agencies. Although installations are obligated to comply only with the prevailing regulations, any performance that exceeds minimum compliance standards would be expected to be recognized and supported by the local jurisdictions.

6.7 APPROACH TO REGULATORY COMPLIANCE AND ACCEPTANCE

Air emissions were the most sensitive environmental issue associated with operation of the mobile planer technology. In a 2004 project involving the MU in Monterey County, CA, both airborne lead and diesel exhaust emissions were monitored, and the results were submitted to the MBUAPCD. The MBUAPCD issued a permit to operate the MU for that project.

The prevailing air quality regulation at the demonstration site, and throughout California, is Article 1, Chapter 3, Part 4, Division 26 of the Health and Safety Code of the State of California. Work outside California will fall under the state and local air quality or emissions regulations applicable to the project site.

Lead hazard was also an important environmental issue relative both to waste disposal and occupational safety. However, lead safety requirements are well known within the construction industry, and safety practices are routine. At the demonstration site, Title 22, Division 4.5, Chapter 11, Article 3, section 66261.24 of the CCR applies to characterize the allowable level of toxicity. At the federal level, toxicity in waste is regulated by RCRA, which is part of 42 U.S.C. §§6901–6992k. Occupational safety with regard to lead exposure of workers is regulated by 29 CFR 1926.62(b), Construction Safety Standards, Part 62 Lead in Construction, and Cal-OSHA 8 CCR 1532.1, Cal-OSHA Construction Industry Lead Standard.

Other relevant environmental and health issues, such as asbestos abatement, are not directly related to operating the mobile planer unit but are regulated as standard practice within the construction industry. Therefore, those issues are not discussed here; environmental protection construction specifications articulate these requirements. One example used by federal agencies is Unified Facilities Guide Specifications (UFGS) 01 57 20.00 10, Environmental Protection.

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7.0 REFERENCES

ASTM E1728. *Standard practice for field collection of settled dust samples using wipe sampling methods for lead determination by atomic spectrometry*, West Conshohocken, PA: ASTM International.

ASTM E1728-03. *Standard practice for collection of settled dust samples using wipe sampling methods for subsequent lead determination*, West Conshohocken, PA: ASTM International.

ASTM E1792. *Standard specification for wipe sampling materials for lead in surface dust*, West Conshohocken, PA: ASTM International.

Code of Federal Regulations, Title 29, Part 1910. Occupational safety and health standards.

Code of Federal Regulations, Title 29,Part 1926. Safety and health regulations for construction.

Guy, G. Bradley. January 2003. *A guide to deconstruction*. Gainesville, FL: M.E. Rinker, Sr. School of Building Instruction, College of Design, Construction, and Planning, University of Florida.

Engineer Manual EM 385-1-1, 2003. November 2003. *Safety – Safety and health requirements*. Washington, DC: Headquarters, U.S. Army Corps of Engineers.

Falk, Robert H., John J. Janowiak, Stephen D. Cosper, and Susan A. Drozdz. 2005. "Remilling of salvaged wood siding coated with lead-based paint: Part 1 – Lead exposure." *Forest Products Journal*, July/August 2005.

Falk, Robert H., John J. Janowiak, Richard G. Lampo, Thomas R. Napier, Stephen D. Cosper, Susan A. Drozdz, Steven Larson, and Edgar D. Smith. September 2006. *Investigation of mechanical processes for removing lead-based paint (LBP) from wood siding*. ERDC-CERL TR-06-30. Champaign, IL: U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory.

ISO 14001:2004(E) International Organization for Standardization (ISO). 1996. Environmental management systems – Specification with guidance for use. Geneva Switzerland: International Organization for Standardization.

Unified Facilities Guide Specification (UFGS) 01451A. January 2003. Contractor quality control. Washington DC:

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APPENDIX A

POINTS OF CONTACT

Point of Contact	Organization	Phone Fax E-Mail	Role
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